

## **LIGHT-GUIDING APPARATUS FOR AN ILLUMINATION SYSTEM**

### **BACKGROUND OF THE INVENTION**

#### **5 Field of Invention**

The present invention relates to a projector. More particularly, the present invention relates to a light-guiding apparatus for an illumination system.

#### **Description of Related Art**

10 Since optical projectors ~~have been~~were developed, they have been applied in many fields. They serve an ~~ever expanding~~ever expanding range of purposes, from ~~consumer~~ption products to high technology, such as ~~using~~by ~~projective~~projective systems for projecting enlarged images, or incorporating a projection screen or television for projecting and displaying ~~enlarged~~real ~~still~~still images or motion pictures ~~real~~real time images ~~of~~with presentations ~~on~~on a projection screen during conferences.  
15 However, as projector applications broaden, demands on contrast and brightness of projectors are also ~~increase~~higher. An illumination system of a projector mostly determines ~~the~~the contrast and brightness ~~of a projector~~thereof are mostly determined by its illumination system.

20 Fig. 1 is a schematic view of an illumination system and a guiding apparatus of a conventional illumination system and light-guiding apparatus. In ~~an~~the existing framework of the conventional illumination and guiding apparatus, light emitted from a light source 102 is collected and reflected by an ellipsoidal reflector 104 to pass through a color wheel 106, and then enters a light tunnel 108.  
25 An outlet of light tunnel 108 is square-shaped, so light is uniformly emitted from

the light tunnel 108 with a square shape cross section after being reflected many times inside the light tunnel 108.

Afterward, ~~t~~The square-section light passes through a relay lens 110 composed of several lenses and a light path turning device 112 to arrive at a 5 digital micro-mirror device (DMD) chip 114. The light path turning device 112 in Fig. 1 is a total internal reflection (TIR) prism. An image generated from the DMD chip 114 is turned by the light path turning device 112, and then is projected to a screen 118 by a projection lens 116.

10 The relay lens 110 in Fig. 1 is a light-guiding apparatus for transmitting light from the light tunnel 108 to the DMD chip 114. The conventional light-guiding apparatus, such as the relay lens 110 composed of several lens, is used to modify the square-section light emitted from the light tunnel 108 to fit match an 15 incident angle and an effective dimension of the DMD chip 114. The relay lens 110 usually is composed of more than three lenses. However, an aberration problem of the relay lens 110 itself twists or blurs edges of the square-section light, thus causing the light spot to be irregular. Furthermore, the light from the 15 light source 102 includes many different wavelengths and these different wavelengths of light generate a chromatic aberration problem while passing through the relay lens 110.

20 Though the aberrations are reduced by optical designs to raise improve image quality, the multiple lenses are complicated in design and expensive. In addition, if more lenses are added to the relay lens 110 to compensate for the aberrations, light intensity is unavoidably lost, which and the less lowers the performance of a projector.

## SUMMARY OF THE INVENTION

5 It is therefore an objective of the present invention to provide a light-guiding apparatus for an illumination system that resolves the aberration problems of a conventional light-guiding apparatus of an illumination system in a projector.

10 In accordance with the foregoing and other objectives of the present invention, a light-guiding apparatus for an illumination system is described. The invention provides an ellipsoidal reflector to as replacement for the conventional relay lens. Light emitted from the light tunnel is reflected to and focused on a DMD chip by the ellipsoidal reflector. The light tunnel and a long axis of the ellipsoidal reflector form an angle. The angle and an eccentricity of the ellipsoidal reflector are used to modify the light emitted from the light tunnel. Thus, the light 15 is made to fit match an incident angle and an effective dimension of a digital micro-mirror device receiving the light when the light arrives at the digital micro-mirror device.

20 In one preferred embodiment of the present inventions, the ellipsoidal reflector is a partial ellipsoid casing, and with a dimension thereof must be larger than a dimension of light emitted thereon by a divergent angle of the light tunnel, thus reflecting light completely. Moreover, the invention further provides an optical compensation device, such as a wedge prism or a compensation lens, on a light path between the ellipsoidal reflector and the DMD chip to compensate for an asymmetric aberration generated by the ellipsoidal reflector.

In another preferred embodiment of the present inventions, two ellipsoidal reflectors are used to guide light in this preferred embodiment, and the asymmetric aberration is reduced by modifying relative angles and eccentricities of the two ellipsoidal reflectors to make the light spot uniform. Moreover, light in 5 this preferred embodiment is completely transmitted by reflection and the chromatic aberration therefore does not exist.

The invention uses an ellipsoidal reflector to replace a conventional relay lens, so as to prevent the chromatic aberration caused by the conventional relay lens. In addition, an optical compensation device that affects the chromatic 10 aberration less is provided to resolve the aberration at the same time. Furthermore, a framework with two ellipsoidal reflectors provides a light spot with no chromatic aberration and the smallest possible spherical aberration on the DMD chip.

The invention uses reflections to guide light, thus enhancing light intensity 15 substantially, and improving the efficiency of a light-guiding apparatus. And Moreover, the light-guiding apparatus of the invention is easier to design than the conventional relay lens composed of several lenses, and Since it includes fewer devices, the invention is easily maintained and cheaper to produce.

It is to be understood that both the foregoing general description and the 20 following detailed description are examples, and are intended to provide further explanation of the invention as claimed.

## BRIEF DESCRIPTION OF THE DRAWINGS

These and other features, aspects, and advantages of the present invention will become better understood with regard to the following description, appended claims, and accompanying drawings where:

5

Fig. 1 is a schematic view of an illumination system and a light-guiding apparatus of a conventional illumination system and light-guiding apparatus;

Fig. 2 is a schematic view according to one preferred embodiment of this invention;

10 Fig. 3A is a schematic view according to another preferred embodiment of this invention;

Fig. 3B is a schematic view according to another preferred embodiment of this invention; and

15 Fig. 4 is a schematic view according to another preferred embodiment of this invention.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

20 Reference will now be made in detail to the present preferred embodiments of the invention, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers are used in the drawings and the description to refer to the same or like parts.

The present invention provides a light-guiding apparatus for an illumination system to resolve the aberration problems of a conventional light-guiding apparatus of an illumination system in a projector.

The invention provides an ellipsoidal reflector as-to replacement for the conventional relay lens 110 in Fig. 1. Light emitted from the light tunnel is reflected and focused onto a DMD chip by the ellipsoidal reflector. The light tunnel and a long axis of the ellipsoidal reflector form an angle. The angle and an eccentricity of the ellipsoidal reflector are used to modify the light emitted from the light tunnel. Thus, the light is made to fit match an incident angle and an effective dimension of a digital micro-mirror device receiving the light when the light arrives at the digital micro-mirror device.

Fig. 2 is a schematic view of one embodiment of the invention. An outlet of a light tunnel 108 is located at a first focus 222 of an ellipsoidal reflector 210, and the light tunnel 108 and a long axis 212 of the ellipsoidal reflector 210 form an angle 214. By the optical reflection characteristic of the ellipsoid, the ellipsoidal reflector 210 collects and reflects light emitted from the light tunnel 108 located at the first focus 222 to another focus of the ellipsoidal reflector 210. However  
But, in fact, the light must pass through a light path turning device 112 before arriving at another  
the other focus, and the light path turning device 112 slightly changes the propagation path of the light, so that a DMD chip 114 for receiving the light does not overlay with another  
that other focus of the ellipsoidal reflector 210.

Because an dimension and an divergent angle 216 of light emitted from the outlet of the light tunnel 108 are constant, the invention modifies the light emitted from the light tunnel 108 by the angle 214 and an eccentricity of the ellipsoidal reflector 210 to fit match an incident angle and an effective dimension

of a digital micro-mirror device. The ellipsoidal reflector 210 is a partial ellipsoid casing, and with a dimension thereof must be larger than a dimension of light emitted thereon from the divergent angle 216, thus reflecting light completely. In this embodiment, the light path turning device is a TIR prism; however, other light path turning devices of other types also can also be used in the invention, which is not limited by this embodiment.

When the ellipsoidal reflector 210 of the invention is used to replace the conventional relay lens 110 (as illustrated in Fig. 1), the chromatic aberration generated by different wavelengths of light passing through the lens is prevented because the light is directly reflected by the ellipsoidal reflector 210. The loss of light intensity caused by light passing through several lenses is also reduced.

Nevertheless, light from the light tunnel to the ellipsoidal reflector 210 is off-axis, which means that light is not emitted along an axis of symmetry of the ellipsoidal reflector 210, so a light spot reflected by the ellipsoidal reflector 210 on the DMD chip 114 is not uniform. This is called an asymmetric aberration. The invention further provides an optical compensation device on a light path between the ellipsoidal reflector 210 and the DMD chip 114 to make the light spot on the DMD chip 114 uniform.

Fig. 3A is a schematic view of another preferred embodiment of the invention. The preferred embodiment provides a wedge prism 302 in the embodiment Fig. 2 to compensate for the asymmetric aberration caused by the ellipsoidal reflector 210. Light first is emitted from the light tunnel 108 and reflected by the ellipsoidal reflector 210, and then arrives at the wedge prism 302. Since light is transmitted at different velocities in different media, a variation of a thickness of the wedge prism 302 is used to adjust the path of light. Lengths of

light paths of different areas in the wedge prism 302, through which light is transmitted, are therefore adjusted to reduce the asymmetric aberration of the light spot on the DMD chip 114.

Fig. 3B is a schematic view of another preferred embodiment of the invention. This preferred embodiment is similar to that illustrated in Fig. 3A, and provides a compensation lens 304 in the embodiment of Fig. 2 to compensate for the asymmetric aberration caused by the ellipsoidal reflector 210. The compensation lens 304 in Fig. 3B is a biconic lens with ~~has~~ two asymmetric axes. The asymmetry of two axes in the compensation lens 304 is used to adjust lengths of light paths along which light is transmitted to reduce the asymmetric aberration generated by the ellipsoidal reflector 210.

The foregoing preferred embodiments provide an optical compensation device, such as a wedge prism 302 or a compensation lens 304 in the light path between the light tunnel 108 and the DMD chip 114 to compensate for the asymmetric aberration generated by the ellipsoidal reflector 210 due to different lengths of the light path along which light is transmitted in media. Though the optical compensation device still causes a chromatic aberration, a thickness of the single optical compensation device utilized here is very thin (concerning the wedge prism 302) and a curvature thereof is very small (concerning the compensation lens 304), so the effect of chromatic aberration is much less than that of the conventional relay lens 110 composed of several lenses.

Fig. 4 is a schematic view of another preferred embodiment of the invention. Two ellipsoidal reflectors are used to guide light in this preferred embodiment, and the asymmetric aberration is reduced by modifying relative angles and eccentricities of the two ellipsoidal reflectors to make the light spot

uniform. Moreover, light in this preferred embodiment is transmitted entirely by reflection, and the chromatic aberration therefore does not exist.

An outlet of the light tunnel 108 is located on a focus 422 of the ellipsoidal reflector 210, and another focus 424 of the ellipsoidal reflector 210 overlays a 5 focus of the ellipsoidal reflector 402. Light emitted from the light tunnel 108 is first collected and reflected to the focus 424 by the ellipsoidal reflector 210. After passing through the focus 424, light is collected by the ellipsoidal reflector 402 and then is reflected to another focus of the ellipsoidal reflector 402. As in the 10 embodiment of Fig. 2, a light path turning device 112 is at another~~the other~~ focus of the ellipsoidal reflector 402. The light path turning device 112 slightly changes 15 the propagation path of the light, so that a DMD chip 114 for receiving the light does not overlay with another~~that other~~ focus of the ellipsoidal reflector 210.

The light tunnel 108 and a long axis 412 of the ellipsoidal reflector 210 form an angle 404, the long axis 412 of the ellipsoidal reflector 210 and a main 15 light path 416 of the light form an angle 406 at the focus 424, and the long axis 412 of the ellipsoidal reflector 210 and a long axis 414 of the ellipsoidal reflector 402 form an angle 408. The angles 404, 406 and 408, and an eccentricity of the 20 ellipsoidal reflector 210 and an eccentricity of the ellipsoidal reflector 402 are used to modify the light emitted from the light tunnel 108 to fit~~match~~ an incident angle and an effective dimension of the DMD chip 114.

The ellipsoidal reflectors 210 and 402 both are partial ellipsoid casings, and with dimensions thereof must larger than dimensions of light emitted thereby to make sure that light is entirely reflected by the ellipsoidal reflectors. In another preferred embodiment, the angle 408 is equal to the sum of the angle 404 and the

angle 406, thus minimizing the aberration of the light spot received by the DMD chip 114.

In conclusion, the invention has the following advantages:

1. The invention replaces a conventional relay lens with an ellipsoidal reflector, so as to prevent the chromatic aberration caused by the conventional relay lens. In addition, an optical compensation device that affects the chromatic aberration less is provided to resolve the aberration at the same time. Furthermore, a framework as in the foregoing embodiment of Fig. 4 with two ellipsoidal reflectors is provided to provide produce a light spot with no chromatic 10 aberration and the smallest possible spherical aberration on the DMD chip.

2. In the conventional framework with a relay lens, light needs to pass through the several lenses, and the loss of light intensity is hard to avoid. The invention uses reflections to guide light, thus enhancing reducing light intensity loss substantially, and improving the efficiency of the light-guiding apparatus.

3. The light-guiding apparatus of the invention is easier to design than the conventional relay lens composed of several lenses, and includes fewer devices. It is therefore easily maintained and cheaper to produce.

It will be apparent to those skilled in the art that various modifications and variations can be made to the structure of the present invention without departing 20 from the scope or spirit of the invention. In view of the foregoing, it is intended that the present invention cover modifications and variations of this invention provided they fall within the scope of the following claims and their equivalents.